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PLASMOCHEMICAL METHODS OF PRODUCTION AND TREATMENT OF MATERIALS

Morphology of Polymer Film Coatings Produced in a Barrier Gas Discharge at Atmospheric Pressure

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Abstract—The technique of deposition of polymer films from the barrier gas discharge plasma on top of dielectric substrates is developed. The film precursor is a monomer material highly dispersed in a transport plasma gas. The plasma formation of the continuous polymer film can be divided into two stages. The first stage is deposition of liquid monomer droplets with subsequent polymerization on the dielectric barrier surface resulting in growth of a discontinuous film. It is found that the ratio of the height of droplets to their lateral size is almost constant and for polystyrene it is equal to ~0.01. The second stage is expansion of the droplets into islands and their coalescence into a continuous polymer film on the dielectric barrier surface. The polymer coating thickness and the amount of cross bonds essentially depend on the current density and concentration of the monomer in the transport discharge gas. A continuous polymer film, which is not contaminated with the monomer destruction products, can be obtained in the current density range of 7–25 mA/cm^2. Experiments with several monomers, like methylmethacrylate, styrene and acrylonitrile, have shown that the growth rate is maximal for monomers with oxygen-free molecules. At the same time, a higher growth rate provides low cross-bond coatings, whereas to get high density of the cross-linked bonds one has to utilize low deposition rates. The minimal thickness at which continuity of the film is achieved increases when the monomer concentration in the plasma rises. In general, the coating thickness depends linearly on the discharge current density; the particular figures depend on the type and concentration of the monomer. The technological parameters are established and given for the three aforementioned monomers.

Keywords: polymer films, barrier discharge plasma
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INTRODUCTION

One of the promising approaches to the preparation of polymer film coatings with the required physicochemical properties is based on plasma chemical technologies [1–3]. In particular, in [4–6], physicochemical aspects of the preparation and modification of polymer materials were considered, as exemplified by polystyrene and its copolymers in low-temperature plasma of both low and atmospheric pressure. By choosing the parameters of gas discharge, one can vary the characteristics of polymer film coatings, for example, their thickness [7]. When using plasma chemical technologies, the maximum thickness of the layer is limited from above, which is due to the competition of polymerization and destruction of the polymer film in the gas discharge and the predominance of the destruction with an increase in its thickness [2]. These processes depend on a large number of parameters, the main ones of which are the gas discharge current density j, the concentration C of monomer, the type of carrier gas, and the intrinsic time of the continuous film formation. In order to prepare polymer film coatings with the given thickness which do not contain the products of polymer destruction [2], it is necessary to provide quasi-optimal values of these parameters.

The formation of a continuous polymer film in the plasma of a barrier gas discharge by the deposition and polymerization of particles (finely dispersed droplets)